Research Productivity of Indian Institute of Science (IISc): A Scientometric and Altmetric Analysis

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Introduction

Research activities act as the foundation for the growth and development of any nation. They generate new information which in turn results in new inventions, technologies, innovations, policies, and so on. Research activities provide the necessary information to make informed decisions. Informed decisions lead to the overall development of the modern world. Realising their importance, countries across the globe spend a considerable amount of their resources on research and development activities. Various academic and research institutions carry out different types of research work to develop knowledge in different fields. Such works, especially in the fields of science and technology, pave the way for the development of the modern world. Continuous assessment of research works is essential for ensuring their quality and relevance in the modern world.

The research productivity of an institution is assessed using various quantitative and qualitative measures. It is often measured by the total research expenditures, number of research papers published, patents filed, research grants received, and the impact of its research on the scientific community and beyond. All of these factors should be considered for a comprehensive mapping of an institution’s productivity. Scientometrics is a field of study that focuses on the quantitative analysis of scientific and technological knowledge. It involves the use of statistical and mathematical methods to analyse the communication of information in any discipline of science and technology. This field is particularly useful in understanding the productivity of a scientific institution, which can be measured in terms of its research output.

The researcher aims to use the methods of scientometrics and altmetrics for mapping the research productivity of Indian Institute of Science, Bangalore. Scientometric analysis forms the cornerstone of this study, providing insights into the citation patterns, collaboration networks, and disciplinary strengths of IISc's

research output. By analysing publication data from the esteemed academic database Scopus, the researcher aims to uncover trends in research productivity, citation impact, and international collaboration, thereby painting a comprehensive picture of IISc's scholarly influence within the global scientific community. However, recognizing the limitations of traditional citation-based metrics in capturing the diverse forms of scholarly impact, this study also incorporates altmetrics into its analytical framework. Altmetrics offers a dynamic and real-time assessment of research impact by tracking online mentions, downloads, social media engagement, and media coverage of scholarly outputs. By harnessing the power of altmetrics data of the top cited IISc publications from the Dimensions database, the researcher seeks to elucidate the broader societal impact and public engagement with IISc's research endeavours.

This study will provide valuable insights into the institution's research strengths and areas for improvement. It will also offer a benchmark for comparing the institution's performance with other similar institutions. The findings of this study could be instrumental in shaping the institution's research policies and strategies, thereby enhancing its productivity and impact in the future.

The researcher hopes that this study will contribute to the broader understanding of research productivity in the scientific community and serve as a useful resource for policy-makers, researchers, and administrators in the field of science and technology.

Scientometrics

There are several definitions of scientometrics given by different researchers, such as Hess, Tague-Sutcliffe, Nalimove and Mulchenko, etc. Scientometrics can be defined as the “quantitative study of science, communication in science, and science policy” (Hess, 1997).

According to J.M. Tague-Sutcliffe (1992), “Scientometrics is the study of the quantitative aspects of science as a discipline or economic activity. It is a part of the sociology of science and has application to science policymaking. It involves quantitative studies of scientific activities, including, among others, publication, and so overlaps bibliometrics to some extent.” Nalimove and Mulchenko (1969) defined "scientometrics as a subfield which applies quantitative methods to the study of science as information process".

Scientometrics is a field of science that focuses on assessing the quality and characteristics of scientific output. It involves analysing research structures, resource inputs, and outputs to establish benchmarks for evaluating the quality of information produced. Scientometric studies provide insights into the development patterns and attributes of different disciplines, making them particularly valuable for assessing emerging fields. In the field of information science, scientometric analyses of scientific publications have become increasingly important. Bibliometric analyses, such as authorship patterns, citation analysis, and coverage of secondary publications, help to understand the dynamics of a particular area, leading to better organization of information resources for effective utilization. Scientometric tools, such as citation mapping, visualization, bibliographic coupling, co-authorship networks, and co-words mapping, are essential for conducting accurate qualitative and quantitative analyses of scientific literature.

Altmetrics

Altmetrics, or alternative metrics, refer to non-traditional measures of scholarly impact that go beyond traditional citation-based metrics such as impact factor or h-index. Altmetrics provides a more comprehensive view of the influence and reach of scholarly outputs by considering various online activities and interactions. These can include social media mentions, downloads, bookmarks,

mentions in news articles, and more. Altmetrics are designed to be more timely than traditional citation metrics, providing a faster and more dynamic assessment of a work's impact. Several major providers offer altmetric data services to researchers, institutions, and publishers. These providers track and analyse online attention and engagement with scholarly outputs. Some of the prominent altmetric data providers include Altmetric, Plum Analytics, Dimensions and Crossref Event Data among others. It is essential to use altmetrics in conjunction with traditional metrics to obtain a well-rounded perspective on research impact. The combination of altmetrics and scientometric approaches contributes to a more robust and contemporary evaluation of scholarly influence.

Indian Institute of Science

The Indian Institute of Science (IISc) was established in 1909 by a visionary partnership between the industrialist Jamsetji Nusserwanji Tata, the Mysore royal family and the Government of India. Over the last 111 years, IISc has become India's premier institute for advanced scientific and technological research and education. Its mandate is "to provide for advanced instruction and to conduct original investigations in all branches of knowledge as are likely to promote the material and industrial welfare of India." In keeping with this guiding principle, the Institute has strived to foster a balance between the pursuit of basic knowledge and applying its research for industrial and social benefit. IISc's reputation and pre-eminence attract the best young faculty members trained in the best laboratories around the world. In 2018, IISc was selected as an Institution of Eminence (IoE) by the Government of India, and it consistently figures among the top Indian institutions in world university rankings.

IISc's research output is diverse, interdisciplinary and cuts across traditional boundaries. The Institute has over 42 academic departments and centres that come

under six divisions. It also places equal emphasis on student learning, with about 4000 students pursuing several postgraduate and PhD programmes, as well as a dedicated four-year undergraduate programme aimed at providing research-oriented training for young students in the basic sciences.

IISc has a vibrant and diverse campus spread over 440 acres of greenery in the city of Bengaluru (formerly Bangalore), India's hub of high-tech companies (in aerospace, electronics, and information technology), educational and research institutions, and numerous start-ups. It has a recently established office called DIGITS to create a best-in-class IT and networking system. In recent times, IISc has also entered into collaborations with several technology giants to find solutions to problems in strategic areas. Many of its faculty members have established their own start-ups to take their research directly to society.

During its centenary in 2009, IISc acquired a new campus in Challakere taluk, Chitradurga district, Karnataka. The flagship project of this 1,500-acre campus, a training programme for rural science and mathematics school and college teachers, has trained more than 11,000 teachers, and has been recognized as a Centre for Excellence by the Government of India (Indian Institute of Science, 2024).

The Indian Institute of Science (IISc) is particularly selected for the study because of its national importance as a centre of excellence in science. IISc is one of India's oldest research institutes that approached its centenary in 2009 and is a premier scientific institution in the world and is on the global map in terms of excellence in frontier research and education. Since it emerged out of Jamshetji Tata's vision in 1909, it has grown into an advanced research and education centre. The Indian Institute of Science, Bangalore is one of the high-level academic institutes of India which has a research-focused academic environment

that makes it a unique and prestigious research institute of the country. It consistently ranks among the top Indian institutions in global university rankings.

Review of literature

Ummer and Rajgoli (2024) conducted a bibliometric analysis of the research output of ISRO's space science and exploration missions based on the data retrieved from the Web of Science Core Collection database and Google Scholar. The paper utilized a dataset of 592 journal articles on ISRO's four space science and exploration missions published between 2002 and 2021. The analysis included bibliometric indicators such as mission-wise and year-wise distribution of articles, relative growth rate, doubling time of publications, prolific authors, leading institutions, international collaboration, highly ranked journals, highly cited articles, and keyword occurrences. Advanced data visualization tool Vos Viewer was used to generate network maps. The study revealed that the mission output data is utilized not only by ISRO scientists but also by academia and research labs. The mission-wise distribution of articles revealed that ISRO's four space science and exploration missions, including Chandrayaan-1, Mars Orbiter Mission (MOM), AstroSat, and Chandrayaan-2, have generated significant research output. The results demonstrated the visibility of ISRO's space science missions in the scientific literature and provided valuable insights into research trends related to these missions.

Eito-Brun (2023) performed a detailed analysis of CNES' (Centre National d'E´tudes Spatiales) scientific production in aerospace research using bibliometric methods. Data is collected from the Scopus database and analysed using tools like Scival, BibExcel, and VOSviewer. The study utilized indicators such as productivity, collaboration index, and citation analysis to evaluate CNES' scientific output. The dataset consisted of 10,370 documents, including articles

and conference papers authored by CNES staff. The study focused on documents published over a span of nearly six decades, from 1964 to 2021. Keyword analysis and co-occurrence analysis are conducted to identify prevalent topics and research trends within CNES' publications. The number of publications and citations received by CNES has shown a positive trend over the years, indicating the agency's impact on the scientific community. The study highlights CNES' position as a key player in the aerospace research domain and emphasizes the importance of bibliometric analysis in evaluating the contributions of space agencies to the global scientific community.

Krishnan et al. (2023) performed a scientometric analysis of research publications from ICAR-Animal Sciences Research Institutes in India over the period 1998-2020. The study retrieved 13,342 records from the Web of Science database for the period 1998-2020. The analysis included assessing publication trends, productivity rates, citation impacts, international collaborations, top research areas, Relative Growth Rate (RGR), and Doubling Time (DT) of publications. ICAR-IVRI contributed the highest number of research papers and citations, followed by ICAR-NDRI. The top research areas were identified as 'Agriculture,' 'Veterinary Sciences,' and 'Food Science Technology'. Top journals for animal sciences research included 'Indian Journal of Animal Science', 'Indian Journal of Animal Research', and 'Indian Veterinary Journal'. The study indicated progress in the quantity and quality of scholarly literature from ICAR-Animal Sciences Research Institutes. It also recommended further research to encompass all state agricultural universities and traditional universities involved in animal sciences research for a broader national research perspective.

Pal and Bhattacharjee (2022) conducted a scientometric analysis of the research productivity among Central Universities of North-East India. The study retrieved data from the Web of Science database, covering publications from 2012 to 2021.

The data from nine selected Central Universities in North-East India were considered for analysis. The dataset was carefully examined in MS Excel and analysed using R-package bibliometrix. The study revealed the research productivity and impact of the Central Universities in the region. A total of 8848 research contributions and 97107 citations have been observed. It was found that Tezpur University has the highest research publications (2875), followed by NEHU (1609) and Assam University (1436), respectively. A total of 1942 articles from all the selected universities were published in open access. The authorship collaboration index was highest for Mizoram University, followed by Nagaland University and Rajiv Gandhi University. The 'Current Science' and 'RSC Advance' were the most common sources, and 'Chemistry' is the most prominent research area among selected central universities. The study excluded metrics related to print books, book chapters, theses, dissertations, and Ph.D. awards.

Singh et al. (2022) carried out a bibliometric analysis of research output from Indian Institutes of Management (IIMs) over a 10-year period (2010-2019). A total of 5,186 publication records related to 17 IIMs were downloaded from the Scopus database. Parameters such as Total Papers (TP), Total Citations (TC), Citation Per Paper (CPP), and h-index were computed. Thematic areas of research were identified using author keywords, with a focus on the top 500 most frequent keywords. International collaboration, open access, and social media visibility of research output were also assessed. The study highlights the need for IIMs to improve research output and visibility on various parameters. Key thematic areas of research identified include supply-chain management, innovation, emerging markets, social media, and corporate governance. Comparison with top international business schools reveals areas where IIMs lag behind and need support for improvement. The study recommends further analysis of input factors and qualitative aspects.

Kumar and Senthilkumar (2019) performed a scientometric analysis of the research output of the Indian Institute of Science (IISc), Bangalore, for the period 2014-2018. A total of 12,130 research papers published by IISc during 2014-2018 were collected from the Web of Science database for analysis. The data included information on authors, publication sources, citations, collaborating institutions, and countries. Software such as Bibexcel, Pajek, VOSViewer, and Excel were utilized for data analysis, visualization, and interpretation. Scientometric tools were employed to analyse the collected data, including collaboration patterns, prolific authors, core journals, and research areas. Key metrics such as publication trends, citations received, and H-Index of prolific authors were examined. The study found that IISc has the highest research publication (12130) among all NIRF-ranked institutions in India. Engineering (3054), Physics (2530), Chemistry (2236), Material Science (2161), and Computer Science (1127) had major contributions during 2014-18. The study recommended that publications in open-access journals/platforms should be encouraged for wider availability of research publications.

Need and Significance of Study

The research productivity of an academic/research institution is generally evaluated by the various research publications produced by the different departments of the particular institution. The quantity and quality of these publications are the major factors used for determining the institution's research productivity. A scholar's academic performance is also evaluated to a great extent, by the quantity and quality of his/her research publications. An institution must produce research works of high quality to ensure top positions in the national and international rankings. The research works that appeared in reputed peer-reviewed journals are a major factor that determines the position of an institution in national and international rankings. A higher academic ranking is necessary for

getting funds from the Government, attracting efficient people, and bringing prestige to the institution at both national and international levels. Hence, institutions across the world are competing for better ranks and they realize the importance of high-quality research publications to achieve their goal. The fields of science and scientific research have witnessed exponential growth in recent years as modern nations continue to realize their importance in achieving sustainable development. There is a considerable increase in the number of people and institutions engaged in scientific and technological education and research. Hence, analysing the growth of scholarly publications of an institution is an important area of research that helps to assess the institution's performance in the academic world.

Statement of the Problem

Evaluation of the research productivity of an institution highlights the contributions of the institution and the individual scholars engaged in research. Consequently, it is crucial to investigate the research productivity of a university or research institute to understand how effectively they contribute to the generation and dissemination of new knowledge. This study specifically focuses on the Indian Institute of Science (IISc) in Bangalore, which is renowned globally for its educational and research endeavours. It is imperative to assess the quality of research conducted at IISc, the effectiveness of knowledge transmission, and its utilization within the knowledge community. Numerous studies have been conducted over time to evaluate the research productivity of universities and research institutes, providing valuable insights into the intellectual presence of such institutions in society. The present study aims to analyse the research productivity of IISc as indexed in the Scopus database and the analysis is confined to only research articles, conference papers, reviews, book chapters, notes and letters affiliated with IISc. It also aims to conduct an altmetric analysis of the

highly cited research articles produced by IISc. The objective is to measure and analyse the research productivity of IISc, resulting in the chosen problem statement for this study: “Research productivity of Indian Institute of Science (IISc): A Scientometric and Altmetric analysis”.

Definition of Key Terms

The major terms used in the study are explained below:

Research productivity:

Merriam-Webster dictionary (2024) defines research as the investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws.

Cambridge dictionary (2024) defines productivity as the rate at which a country, company, etc. produces goods or services, usually judged in relation to the number of people and the time necessary to produce them.

In the present study, research productivity refers to the output of academic or scientific work produced by the institution. It is often measured by the number of publications produced by the institution’s researchers over a given period.

Scientometrics: According to J.M. Tague-Sutcliffe (1992), “Scientometrics is the study of the quantitative aspects of science as a discipline or economic activity. It is a part of the sociology of science and has application to science policymaking. It involves quantitative studies of scientific activities, including, among others, publication, and so overlaps bibliometrics to some extent.”

Altmetrics: In scholarly and scientific publishing, altmetrics are non-traditional bibliometrics proposed as an alternative or complement to more traditional citation impact metrics, such as impact factor and h-index. The term altmetrics

was proposed in 2010, as a generalization of article-level metrics, and has its roots in the #altmetrics hashtag. (Wikipedia Contributors, 2024)

Analysis: Merriam-Webster dictionary (2024) defines analysis as a detailed examination of anything complex in order to understand its nature or to determine its essential features.

Objectives of the study

The objectives of the study are as follows:

1. To study the year-wise distribution of research output produced by IISc.

2. To investigate citation patterns of the scholarly output of IISc to identify highly cited works.

3. To find out the number of citations received and the H-Index of the prolific authors.

4. To find out the most collaborating countries and institutions with IISc in research.

5. To identify highly preferred journals in which authors prefer to publish their research works.

6. To find out the top funding agencies for project-based research.

7. To explore emerging research topics and thematic trends within the scholarly output of IISc.

8. To analyse the co-authorship patterns among authors, countries and institutions associated with IISc's research output.

9. To examine the co-occurrence patterns of author keywords within IISc's research output.

10. To systematically measure and analyse the online attention received by the highly cited publications of IISc using altmetrics data.

Methodology of the study

The present study attempts to investigate the research productivity of Indian Institute of Science, Bangalore. The study uses the methods of scientometrics to analyse all the research articles, conference papers, reviews, book chapters, notes and letters affiliated with IISc and indexed in the Scopus database. The study also uses altmetric analysis to analyse the online attention received by the highly cited articles of IISc. The Indian Institute of Science (IISc) has been specifically chosen for investigation due to its significant position as a centre of excellence in the fields of science and research. IISc, which celebrated its centenary in 2009, is among the prominent research establishments in India and is globally recognized for its exceptional contributions to cutting-edge research and education.

The study aims to collect publication data from the Scopus bibliographic database. This data will include the number of publications, the number of citations, details of authors, funding institutions and so on. The data will be downloaded in different formats from the Scopus database for analysis. The study will then use scientometrics to analyse the research output of the institute. Scientometrics is the study of the quantitative properties of scientific literature. It can be used to measure the impact of research, to identify emerging research areas, and to track the careers of individual researchers.

Altmetrics data will be collected from the Dimensions database using the DOI of publications. Altmetrics data measures the online attention that a piece of research receives, including social media mentions, news article views, and blog post shares. The study will use altmetrics to analyse the online attention that the institute's research receives.

The collected data will be tabulated and analysed using software like MS Excel, VOSviewer and so on. The results of the study will be used to evaluate the research productivity of the institute and to identify areas for improvement. It will be used to identify research clusters, to track the diffusion of ideas, and to measure the impact of individual researchers. The study will also provide valuable insights into the online impact of the institute's research and collaboration patterns of its scholars.

Scope and limitations of the study

The study is limited to the research articles, conference papers, reviews, book chapters, notes and letters of the Indian Institute of Science Bangalore, which is indexed in the Scopus database. The Scopus database follows its own standards for the inclusion or omission of items or periodicals in its coverage. Since this study is only based on the Scopus database, it may not capture all of the research that is produced by the institute. The study is also limited to the altmetrics data that is available in the Dimensions database. This means that the study may not capture all of the online attention that the institute's research receives. The accuracy, validity, and reliability of the findings depend upon the information provided by Scopus and Dimensions databases. Therefore the results and conclusions have to be interpreted with the above constraints in view. Despite these limitations, the study is still valuable because it provides a snapshot of the research productivity of the institute. The study can be used to identify areas for improvement and to track the progress of the institute over time.

Conclusion

The study "Research productivity of Indian Institute of Science (IISc): A Scientometric and Altmetric Analysis" aims to comprehensively examine the scholarly influence of the Indian Institute of Science. By combining traditional scientometric methods with contemporary altmetric indicators, the study seeks to provide a holistic understanding of the institute's impact within the academic community and in the broader public sphere. The inclusion of all the research articles, conference papers, reviews, book chapters, notes and letters indexed in the Scopus database allows for the exploration of evolving trends, key milestones, and the transformative impact of the institute's research outputs over time. By embracing both traditional and alternative metrics, the study acknowledges the evolving landscape of scholarly communication and the need for a nuanced assessment of research impact that extends beyond conventional measures. The findings of this analysis hold significance for researchers, administrators, and policymakers associated with the Indian Institute of Science, offering valuable insights into the institute's academic contributions, collaborative networks, and societal reach. Ultimately, the research aspires to shed light on the enduring legacy and contemporary relevance of the Indian Institute of Science as a leading institution in the realm of scientific and scholarly pursuits.

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